ELSEVIER

Evolution and Human Behavior 25 (2004) 125–132

Evolution and Human Behavior

Second to fourth digit ratio and facial asymmetry

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Received 4 July 2001; accepted 8 November 2003

Abstract

Several studies have reported a positive association between degree of facial symmetry and attractiveness ratings, although the actual causes of the development of facial asymmetries remains to be confirmed. The current study hypothesizes that early hormone levels may play a crucial role in the development of facial asymmetries. Recent evidence suggests that the relative length of the second to fourth finger (2D:4D) is negatively related to prenatal testosterone and positively related to prenatal estrogen and may thus serve as a window to the prenatal hormonal environment. We measured 2D:4D in a sample of male and female college students and analysed their faces for horizontal asymmetries. 2D:4D was significantly negatively related to facial asymmetry in males, whereas in females facial asymmetry was significantly positively related to 2D:4D. We suggest that digit ratio may thus be considered as a pointer to an individual's developmental instability and stress through its association with prenatal sexual steroids.

Keywords: Digit ratio; Symmetry; Developmental stability; Face; Humans

1. Introduction

Bilateral symmetry of physical traits is hypothesized to reflect overall quality of development, especially the ability to resist environmental perturbations during development

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1090-5138/04/$ – see front matter

doi:10.1016/S1090-5138(03)00084-9

(Møller & Swaddle, 1997). Hence, a symmetrical face may signal developmental homeostasis, the ability of an individual to cope with the challenges of its environment (Grammer & Thornhill, 1994). Several studies have shown a relationship between symmetry and attractiveness. If symmetry is present in the face or the body an individual is judged as being relatively attractive, and if the body is asymmetric the face is rated unattractive, even if the rater never sees the body (Gangestad, Thornhill, & Yeo, 1994; Thornhill & Gangestad, 1993, 1994).

Facial asymmetries manifest themselves very early in human development and remain stable during one's lifetime (Thornhill & Gangestad, 1996; Thornhill & Møller, 1997). These minor physical anomalies (MPAs) seem to be the result of developmental instabilities during early embryonic development. MPAs are formed in the first trimester of gestation, and fluctuating asymmetries develop throughout life. However, several studies have shown positive correlations between the frequency of MPAs and fluctuating asymmetry (see for a review, Grammer, Fink, Møller, & Thornhill, 2003).

It is well established that poor environmental conditions increase developmental instability and measures of fluctuating asymmetry (see Thornhill & Møller, 1997). Adverse environmental conditions are also known to reduce immunocompetence. It is further likely that sex hormones are one factor mediating the relationship between immune defence and developmental stability. Facial secondary sexual characteristics appear to advertise phenotypic and genetic quality because of their connection to sex hormones. Previous studies on human physical attractiveness suggest that testosterone (T) as well as estrogen (E) may negatively impact immunocompetence when present in high titers (Folstad & Karter, 1992). High titers of sex hormones are, however, necessary to produce attractive physical features such as broad jaws in males or high cheekbones in females. Consequently, attractive features such as facial symmetry, developed under the presence of sex steroids, are thought to advertise immunocompetence honestly (Grammer & Thornhill, 1994).

Males produce testosterone prenatally, particularly from around gestation week 8 to 24, and for approximately the first 6 months postnatally (Migeon & Wisniewski, 1998). Female fetuses probably produce estrogens, although it is unclear how much of a contribution the fetal ovary makes to development. There is accumulating evidence that the ratio between the length of the index finger (2D) and the ring finger (4D) is negatively related to prenatal T and positively related to prenatal E (for a review, see Manning, 2002).

The aim of the present study was to determine whether there is an association between human finger length patterns and facial asymmetry in males and females. As 2D:4D is thought to be a pointer to the early hormonal environment, we hypothesized that in males 2D:4D would be negatively related to facial asymmetry scores (as a result of T), whereas in females 2D:4D should be positively related to facial asymmetry (as a result of E). If this hypothesis were true, digit ratio could serve as identifier of prenatally elevated T and E levels as causes for an early manifestation of fluctuating asymmetries in the face. We discuss our findings within the evolutionary framework of sexual selection of human physical characteristics.

2. Materials and methods

2.1. Participants and digit measures

We measured the lengths of the second and fourth finger and the degree of facial asymmetry (as a measure of facial developmental instability) in a sample of 69 heterosexual males (mean age=21.72) and 85 females (mean age=21.98) aged 17 to 38 years. Photocopies were made of the ventral surface of the hand. Participants were asked to place their hands palm down on the centre of the glass plate of the photocopier and one photocopy per hand was made. Care was taken to ensure that details of major creases could be seen on the hands. When quality was poor, a second photocopy was made. From the photocopies, we measured the lengths of the second and fourth digits of the left and right hands from the ventral proximal crease of the digit to the tip. Where there was a band of creases at the base of the digit, we measured from the most proximal of these. In order to establish repeatabilities, the second and fourth digits were measured directly from the hand and from the photocopies. All measurements were made with digital Vernier calipers measuring to 0.01 mm. Those participants who reported injuries to the second or fourth digits (including injuries to the carpus and disruption of tendons) were discarded from the final analyses, as were participants who identified themselves as homosexual or bisexual, or left-handed, so that our final sample number was 54 heterosexual males and 68 heterosexual females.

In comparisons between 2D:4D ratios calculated from measurements made on the hand and those made from photocopies we used repeated measures ANOVA and Model II single factor ANOVA (Zar, 1984) to calculate intraclass correlation coefficients (r_1) and the ratio (F) between measurement error (the differences between successive measures of 2D:4D) and between-participant differences.

$$r_1 = (\text{groups MS} - \text{error MS})/(\text{groups MS} + \text{error MS})$$

where MS=mean squares. We found that between-individual differences were significantly greater than measurement error in 2D:4D (right hand r_1=.68, F=5.27, P=.0001; left hand r_1=.61, F=4.15, P=.0001). For 30 photocopies, the fingers were measured by two measurers. Intermeasurer reliability was high for both the left (r_1=.97, F=73.64, P=.0001) and the right hand (r_1=.98, F=125.85, P=.0001). We concluded that our calculated values of 2D:4D reflected real differences between individuals.

2.2. Facial photographs

Each participant was seated upright in a chair with a light source on each side of the face in order to prevent shading. We carefully positioned each participant such that all were looking directly into the camera. Distance to the camera remained constant. The picture was taken with a high-resolution digital photo camera in TIFF file format. Picture size was 1024×768 pixels with a resolution of 72 dpi.

2.3. Standardization of images

Digital images were standardized to the same orientation by means of a Procrustes (least square) approach (Bookstein, 1991; Liu, Schmidt, Cohn, & Mitra, 2003; Mardia, Bookstein, & Moreton, 2000). We consider this automated method more accurate than rotating images by hand with commercially available software. The use of the Procrustes methodology for facial standardization has been described in previous studies (Fink, Grammer, & Thornhill, 2001; Grammer, Fink, Juette, Ronzal, & Thornhill, 2001; Rikowksi & Grammer, 1999). In summary, the shape of facial features was defined by manually setting 51 predefined feature points ("landmarks") on each face (=source coordinates), which could be easily identified in every image [landmark placement was made by an experienced person (B.F.) and reliability was tested by comparing the placement accuracy with an untrained student. This resulted in a mean error of 1.5 (S.D.=.8) pixels placement error]. The mean coordinates (=destination coordinates) and the respective landmarks were calculated for all faces. After that, the center of gravity (i.e., for *x*-coordinates: $x_{\text{center of gravity}}$=sum of all *x*-coordinates divided by the number of landmarks; same procedure for *y*-coordinates) of the source coordinates was calculated for each face. Every face was moved on the picture plane so that the center of gravity of a face fell on the center of gravity of the destination coordinates. Using a least squares method (see Bookstein, 1991) faces were then resized and finally rotated about the center of gravity. The result was images that were comparable (equally orientated) in size and rotation but still retained their individual level of facial asymmetry.

2.4. Measurement of facial asymmetry

We used a digital image analysis algorithm for the detection of symmetry in a face, which has been reported to measure facial symmetry accurately in previous studies (see Fink et al., 2001; Grammer et al., 2001). It follows a standard methodology for symmetry detection by means of spatial filtering (see, for details, Dakin & Herbert, 1998; Dakin & Watt, 1994; Liu et al., 2003; O'Mara & Owens, 1996). In brief, a window on the picture was defined by the left and right outer eye corner, top of the brows, and the lower lip. This is the region of interest (ROI) for further calculations. The ROI then was divided into *n* horizontal, 1-pixel-thick slices (*n* refers to the height of the window; it varies because of the differences in the distance between the top of the brows and the lower lip of the single faces). The resulting slices are *n* parts of the original ROI for the detection of symmetry points, each of them with a midpoint at half of the horizontal width of the ROI. Each slice was then moved horizontally across the face at the same vertical location to the right for 50 pixels. (Note: the direction does not influence the calculation.) Then the slice was moved back in 1-pixel steps to the left plus 20 pixels of its original location. At each step, the absolute difference between the sum of grey values of the right and left half of the slice was calculated. The minimum difference between left and right grey value sums then determines the symmetry point. This was repeated for all *n* slices. In a perfectly symmetrical face, the line through all symmetry points is a straight line and equals the distance between top of the brows and lower lip (see also Grammer & Thornhill, 1994).

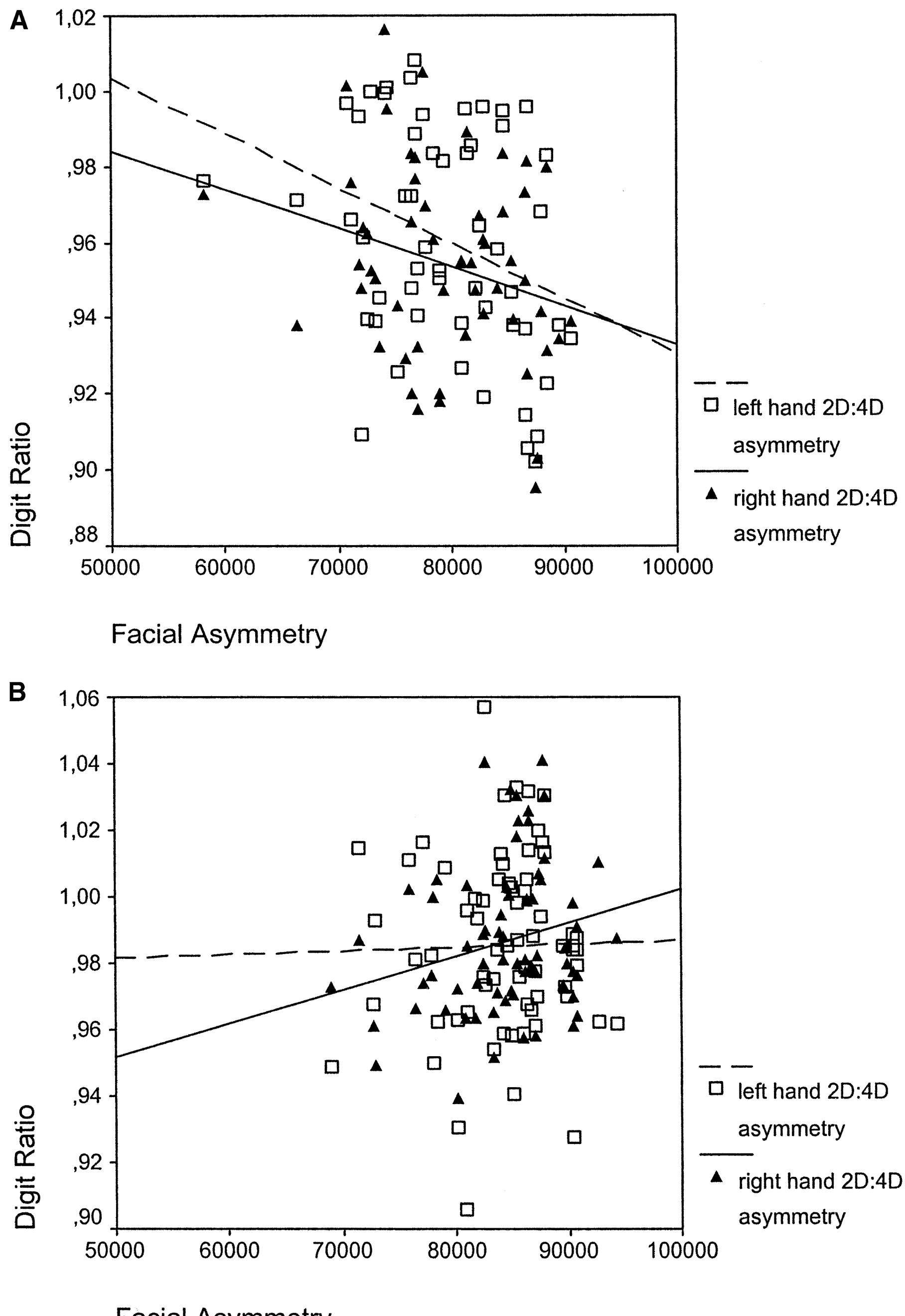

Fig. 1. Scatterplot of right- and left-hand 2D:4D digit length ratios and facial asymmetry in men (a) and women (b). The regression lines are statistically significant except for the left hand of women.

The symmetry index was calculated as the length of the line joining all symmetry points divided by the height of the window.

Unpaired *t* tests were used for determining possible group differences in 2D:4D. If not reported otherwise, one-tailed Pearson correlation coefficients were used for assessing the relationship between 2D:4D and facial asymmetry.

3. Results

In accordance with previous reports (Manning, 2002), males had a significantly lower 2D:4D ratio than females on the right hand but no significant sex difference was found on the left hand (2D:4D right hand: males $x=0.95\pm0.02$, females $x=0.99\pm0.02$, $t=-7.82$, $P<.05$; 2D:4D left hand, males $x=0.96\pm0.03$, females $x=0.99\pm0.02$, $t=-4.92$, $P<.05$). We found that 2D:4D ratio was significantly correlated with facial asymmetry scores in both sexes. Male right-hand 2D:4D ratio correlated significantly negatively with facial asymmetry ($r=-.260$; $P=.029$; see Fig. 1a). Female right hand 2D:4D ratio correlated significantly positively with facial asymmetry, ($r=.228$; $P=.031$, see Fig. 1b). Left hand 2D:4D and facial asymmetry were significantly negative correlated in males ($r=-.319$; $P=.009$), but there was no significant correlation in females ($r=.020$; $P=.436$).

4. Discussion

The aim of this study was to examine possible relationships between finger length ratio (2D:4D) and facial asymmetry in males and females. Male facial asymmetry was negatively correlated with 2D:4D in both hands, but only in the right hand in females. These relationships probably reflect in utero organisational effects of sex steroids on facial asymmetry rather than adult hormone effects.

There is accumulating evidence that 2D:4D is negatively related to prenatal testosterone and positively to prenatal oestrogen. Thus, (1) 2D:4D is sexually dimorphic in children and does not appear to change at puberty, (2) the waist-to-hip ratio of mothers (a positive correlate of testosterone and a negative correlate of oestrogen) is negatively related to the 2D:4D ratio, and (3) sex-dependent traits that express early embryonic development, such as handedness, autism, and Asperger's syndrome, are correlated with 2D:4D (see Manning, 2002, for a review). In addition, children with congenital adrenal hyperplasia, a trait that is characterised by high prenatal androgen, have low 2D:4D ratios (Brown, Hines, Fane, & Breedlove, 2002; Okten, Kalyoncu, & Yaris, 2002). In contrast to the associations between 2D:4D and prenatal sex steroids, there is little evidence that finger ratios correlate with adult sex steroids in general population samples. Manning, Scutt, Wilson, and Lewis-Jones (1998) reported a negative association between 2D:4D and testosterone and a positive correlation between 2D:4D and oestrogen. However, their sample consisted of patients from a fertility clinic, some of whom were likely to have atypical hormonal profiles. Neave, Laing, Fink, and

Manning (2003) did not find an association between 2D:4D and testosterone levels in a normal sample of men.

Developmental stability, or homeostasis, facilitates the production of consistent phenotypes by buffering against stress. Fluctuating asymmetry is produced by developmental instability and is manifested as small random departures from bilateral symmetry. Bilateral symmetry reflects overall quality of development, especially the ability to resist environmental perturbations during development (e.g., Leary & Allendorf, 1989; Parson, 1990), which implies that a symmetrical face displays developmental homeostasis (Thornhill & Gangestad, 1993). Asymmetries may occur during any period in development and appear to be particularly high in children during periods of rapid growth (Wilson & Manning, 1996). The associations we have found between 2D:4D and facial asymmetry suggest that some of the variance in developmental stability of the face is determined in utero by sex steroids and persists into adulthood.

Acknowledgments

The authors thank the editors and two anonymous referees for their helpful comments on earlier versions of the manuscript, and Karin Hasewend for her assistance with data collecting.

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